

# A COLOR FILTER ARRAY HAVING A GREEN FILTER LAYER

## Background of the Invention

The present invention relates to color filter arrays  
5 for solid-state image devices or liquid crystal display  
devices, and to a method for producing the same.

As a color filter array formed on a device such as  
a solid-state image device or a liquid crystal display device,  
there has been known a color filter array (2) constituted  
10 of a red filter layer (R), a green filter layer (G), and  
a blue filter layer (B) formed so as to be adjoining to  
each other in the same plane of a substrate (1) (Figure  
1). In the color filter array (2), the filter layers (R),  
(G), (B) are arranged in a striped pattern (Figure 2) or  
15 a lattice-like pattern (mosaic) (Figure 3).

A variety of processes for producing such color filter  
array have been proposed. Among them, so-called "color  
resist method" is in wide practical use. In the color resist  
method, the patterning is effected by exposing a  
20 photosensitive resin composition comprising colorants to  
light and developing, and the patterning is repeated in  
sequence in the required times.

As the photosensitive resin composition which is  
employed in the color resist method, those employing  
25 pigments as colorants are in wide use. However, such  
pigments are not suitable for the formation of fine or minute  
patterns, for they are granular and do not dissolve in  
developers, and developing residue is generated.

As a photosensitive resin composition for obtaining a finely patterned color filter array, a photosensitive resin composition employing dyes as colorants has also been known. For example, Japanese Patent Application Laid-Open No. 6-75375 discloses a negative photosensitive resin composition comprising dyes, and Japanese Patent Publication No. 7-111485 discloses a positive photosensitive resin composition comprising 10 to 50%, on a dry weight basis, of a dye soluble in the solvent used in the positive photosensitive resin composition.

(Hereinafter, "JP-A-" is used for indicating Japanese Patent Application Laid-Open, and "JP-B-" is used for indicating Japanese Patent Publication.)

Colorants comprised in photosensitive resin compositions used for producing color filter arrays, such as those described above, are required to have the following two properties.

(1) Good spectroscopic characteristics, that is, showing sufficient absorption within the predetermined visible ray region and no unnecessary absorption in the other region.

(2) Good light fastness, that is, no burn-in due to the decolorization of dyes under normal operating conditions

However, none of the dyes employed in conventional photosensitive resin compositions has both of the above-described two properties.

For example, although the green filter layer of a color

filter is desired to have a small transmittance at a wavelength of 450 nm and large transmittance at a wavelength of 535 nm, in the conventional photosensitive resin compositions, attempts to lower the transmittance at 450 nm cause a decrease in transmittance at 535 nm, deteriorating the spectroscopic characteristics. The attempts also cause decrease in transmittance at a wavelength of from 350 to 400 nm. As a result, the amount of exposure energy required for the patterning is raised, causing a reduction in the productivity of color filters.

Such problems of conventional photosensitive resin compositions will be mentioned below more concretely.

A photosensitive resin composition comprising a copper phthalocyanine dye and a pirazolone azo dye (C.I. Solvent Yellow 88) is described in above-mentioned JP-B-7-111485. Both dyes are excellent in light fastness. However, since C.I. Solvent Yellow 88 (pirazolone azo dye) has relatively high absorptivity of near-ultraviolet ray employed for the exposure, the amount of the dye in the composition is limited, and the transmittance of the resulting green filter layer at 450 nm tends to become large. In addition, since the dyes do not have sufficient high transmittance at 535 nm, transmittance with respect to green light of the resulting green filter layer tends to decrease. As a result, color filters having a green filter layer formed by using such photosensitive resin composition were not always satisfactory in their performance. As a matter of fact, according to the gazette, the transmittance of a 2

$\mu\text{m}$ -thick green filter layer formed by using such photosensitive resin composition is 6% at 450 nm, 56% at 535 nm, and 4% at 650 nm.

A colorant having good spectroscopic characteristics 5 is known. However, none of colorants having good spectroscopic characteristics is satisfactory in light fastness. Therefore, it has been difficult to manufacture a color filter array having a practical green filter layer.

The inventors of the present invention have made 10 intensive and extensive studies to develop a color filter array having a green filter layer having good spectroscopic characteristics as well as good light fastness. As a result, they have found that the use of at least two types of specific dyes realizes the formation of a green filter layer 15 satisfactory both in spectroscopic properties and light fastness. The present invention was accomplished based on this finding.

#### Summary of the Invention

20 The present invention provides a color filter array having a green filter layer on a substrate wherein the green filter layer comprises a copper phthalocyanine dye (hereinafter, referred to as "dye (I)") having its absorption maximum at a wavelength 25 of 600 to 700 nm, and a pyridone azo dye (hereinafter, referred to as "dye (II)") having its absorption maximum at a wavelength of 400 to 500 nm; and

has a transmittance at a wavelength of 450 nm of 5% or less and that at 535 nm of 62% or more.

The present invention also provides a process for producing the color filter array.

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#### Brief Description of the Drawings

[Figure 1]

Figure 1 is a schematic view showing a cross-section of a color filter array in which a green filter layer, a red filter layer, and a blue filter layer are provided in the same plane of a substrate.

[Figure 2]

Figure 2 is a plane schematic view of a color filter array provided with a green filter layer, a red filter layer, and a blue filter layer arranged in a striped pattern.

[Figure 3]

Figure 3 is a plane schematic view of a color filter array provided with a green filter layer, a red filter layer, and a blue filter layer arranged in a mosaic pattern.

20 [Figure 4]

Figure 4 is a plane schematic view of the color filter array obtained in Example 1.

[Figure 5]

Figure 5 is a plane schematic view of the color filter array obtained in Example 1.

[Figure 6]

Figure 6 is a schematic view illustrating the steps in Example 4.

[Description of Reference Numerals]

1: substrate  
2: color filter array  
3: over coating film  
5 4: polysilicon electrode  
5: sensor

6: V resistor  
7: light-shielding film  
8: passivation film

10 9: microlens

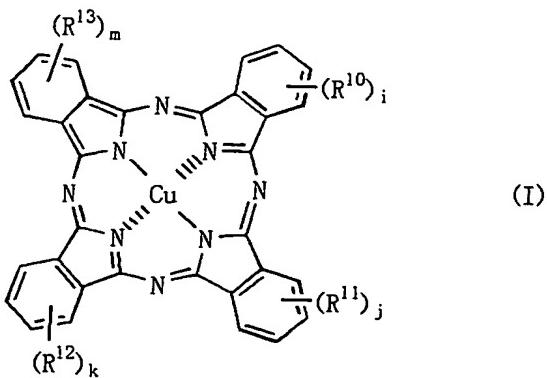
R: red filter layer  
G: green filter layer  
B: blue filter layer

15 Embodiment of the Invention

As the substrate used in the color filter of the present invention, a silicon wafer and a transparent inorganic glass plate are exemplified. On the silicone wafer, a charge coupled device may be formed.

20 The color filter array of the present invention has a green filter layer on its substrate.

The green filter layer comprises a dye (I) having its absorption maximum at a wavelength of 600 to 700 nm, and a dye (II) having its absorption maximum at a wavelength 25 of 400 to 500 nm. Concrete examples of the dye (I) include compounds represented by the general formula (I):



wherein

$R^{10}$ ,  $R^{11}$ ,  $R^{12}$ , and  $R^{13}$  each independently represent a sulfonic acid group or its salt group;  
5 a sulfonamide group; or  
a substituted sulfamoyl group represented by the general formula (1):

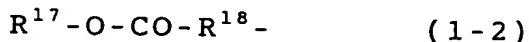


10 Wherein  $R^{14}$  represents  
an alkyl group having 2 to 20 carbon atoms, a cyclohexylalkyl group in which the alkyl chain has 2 to 12 carbon atoms, an alkylcyclohexyl group in which the alkyl chain has 1 to 4 carbon atoms, an alkyl group 15 which has 2 to 12 carbon atoms and has been substituted with an alkoxy group having 2 to 12 carbon atoms, an alkylcarboxylalkyl group represented by the general formula (1-1):



20 wherein  $R^{15}$  represents an alkyl group having 2 to 12 carbon atoms and  $R^{16}$  represents an alkylene group having 2 to 12 carbon atoms  
an alkyloxycarbonylalkyl group represented by the

general formula (1-2):



wherein  $R^{17}$  represents an alkyl group having 2 to 12 carbon atoms and  $R^{18}$  represents an alkylene group having 5 2 to 12 carbon atoms

a phenyl group substituted with an alkyl group having 1 to 20 carbon atoms, or

an alkyl group which has 1 to 20 carbon atoms and has been substituted with phenyl group;

10 and each of i, j, k, m independently represent an integer of 0 to 2 with the proviso that  $i + j + k + m \leq 4$ .

Examples of the group represented by  $R^{14}$  in a compound represented by the general formula (I) are as follows.

Examples of the alkyl group having 2 to 20 carbon atoms

15 include ethyl group, propyl group, n-hexyl group, n-nonyl group, n-decyl group, n-dodecyl group, 2-ethylhexyl group, 1,3-dimethylbutyl group, 1-methylbutyl group,

1,5-dimethylhexyl group, and 1,1,3,3-tetramethylbutyl

group. Examples of the cyclohexylalkyl group in which the

20 alkyl chain has 2 to 12 carbon atoms include cyclohexylethyl group, 3-cyclohexylpropyl group, and 8-cyclohexyloctyl group. Examples of the alkylcyclohexyl group in which the alkyl chain has 1 to 4 carbon atoms include 2-ethylcyclohexyl group, 2-propylcyclohexyl group, and

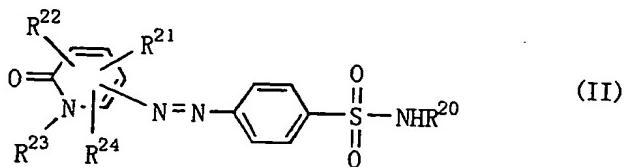
25 2-(n-butyl)cyclohexyl group. Examples of the alkyl group which has 2 to 12 carbon atoms and has been substituted with an alkoxy group having 2 to 12 carbon atoms include 3-ethoxy-n-propyl group, propoxypropyl group,

4-propoxy-n-butyl group, 3-methyl-n-hexyloxyethyl group, and 3-(2-ethylhexyloxy)propyl group. Examples of the phenyl group substituted with an alkyl group having 1 to 20 carbon atoms include o-isopropylphenyl group. Examples 5 of the alkyl group which has 1 to 20 carbon atoms and has been substituted with phenyl group include DL-1-phenylethyl group, benzyl group, and 3-phenyl-n-butyl group.

Examples of the alkyl group having 2 to 12 carbon atoms 10 represented by R<sup>15</sup> in the general formula (1-1) or R<sup>17</sup> in the general formula (1-2) include ethyl group, propyl group, n-hexyl group, n-nonyl group, n-decyl group, n-dodecyl group, 2-ethylhexyl group, 1,3-dimethylbutyl group, 1-methylbutyl group, 1,5-dimethylhexyl group, and 15 1,1,3,3-tetramethylbutyl group. Examples of the alkylene group represented by R<sup>16</sup> or R<sup>18</sup> are dimethylene group, trimethylene group, tetramethylene group, pentamethylene group, and hexamethylene group.

Examples of the dye (I) include C.I. Solvent Blue 25, 20 C.I. Solvent Blue 55, C.I. Solvent Blue 67, C.I. Acid Blue 249, and C.I. Direct Blue 86. These are used singly or in combination. These dyes (I) have their absorption maximum at a wavelength within the range of from 600 to 700 nm.

25 Examples of the dye (II) include compounds represented by the general formula (II):



wherein R<sup>20</sup> represents an alkyl group having 2 to 10 carbon atoms; R<sup>21</sup>, R<sup>22</sup>, and R<sup>24</sup> each independently represents

5 hydrogen atom, methyl group, hydroxyl group, or cyano group; and R<sup>23</sup> represents an alkyl group having 1 to 4 carbon atoms.

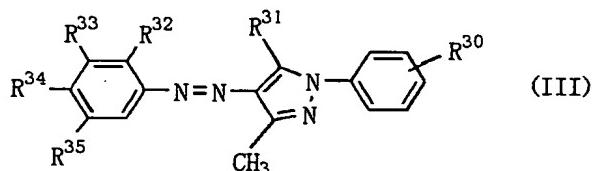
In a compound represented by the general formula (II), examples of the alkyl group having 2 to 10 carbon atoms and represented by R<sup>20</sup> include ethyl group, propyl group, 10 n-hexyl group, n-nonyl group, n-decyl group, n-dodecyl group, 2-ethylhexyl group, 1,3-dimethylbutyl group, 1-methylbutyl group, 1,5-dimethylhexyl group, and 1,1,3,3-tetramethylbutyl group. Examples of the alkyl group having 1 to 4 carbon atoms and represented by R<sup>23</sup> include 15 methyl group, ethyl group, propyl group, and butyl group.

An example of the dyes (II) is C.I. Solvent Yellow 162. Usually, these dyes (II) are less i-ray absorptive, and have their absorption maximum at a wavelenght of 400 to 500 mm.

20 The thickness of the green filter layer and the amounts of the dye (I) and the dye (II) comprised therein are controlled so that transmittance of the filter is 5% or less at a wavelength of 450 nm and 62% or more at 535 nm. For example, by making the green filter layer so as to have 25 a thickness of about 1.6 to 1.9  $\mu\text{m}$  and a dye (I) content of, per a total of 100 parts by weight of the dye (I) and

the dye (II), 30 to 70 parts by weight, preferably 40 to 50 parts by weight, the transmittance of the green filter layer will be 5% or less at 450 nm and 62% or more at 535 nm.

5       For improving light fastness and controlling the color, that is, control of its spectroscopic characteristics, other dyes may be incorporated into the green filter layer. For example, the green filter layer may comprise a pirazolone azo dye which shows its absorption maximum at a wavelength 10 of 400 to 500 nm (hereinafter, referred to as "dye (III)"). Examples of the dye (III) include compounds represented by the general formula (III):



15       wherein R<sup>31</sup> and R<sup>32</sup> each represents hydroxyl group or a carboxylic acid group; R<sup>30</sup>, R<sup>33</sup>, R<sup>34</sup>, and R<sup>35</sup> each independently represents hydrogen atom, a halogen atom, an alkyl group having 1 to 4 carbon atoms, a sulfonic acid group, an alkyl group having 1 to 4 carbon atoms, or nitro group, and salts thereof. Incorporation of the dye (III) further improves the light fastness of the green filter layer.

As the halogen atom represented by R<sup>30</sup>, R<sup>33</sup>, R<sup>34</sup>, or 25 R<sup>35</sup> in a compound represented by the general formula (III), fluorine atom, chlorine atom and bromine atom can be

exemplified. Examples of the alkyl group having 1 to 4 carbon atoms include methyl group, ethyl group, propyl group, and butyl group. Examples of the alkoxy group having 1 to 4 carbon atoms are methoxy group, ethoxy group, propoxy group, and butoxy group.

The dye (III) may be a compound of the general formula (III) or its salt. As the salt, those with alkaline metals such as sodium and potassium or with amines such as triethylamine, 2-ethylhexylamine, and

10 1-amino-3-phenylbutane can be exemplified. When at least one of the groups  $R^{30}$ ,  $R^{33}$ ,  $R^{34}$ , and  $R^{35}$  in a compound represented by the general formula (III) is a sulfonic acid group, usually, its salt is formed at the position of the sulfonic acid group.

15 The dye (III) may form a complex through coordination with a chromium atom. Formation of a complex with a chromium atom further improves the light fastness.

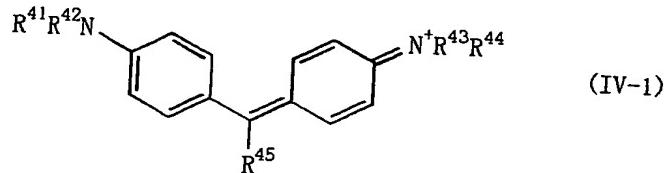
Examples of the dye (III) are C.I. Acid Yellow 17, C.I. Solvent Orange 56, and C.I. Solvent Yellow 82, and 20 these are used singly or in combination. These dyes (III) have their absorption maximum at a wavelength of 400 to 500 nm.

When the dye (III) is used, its content is usually 70 parts by weight or less per a total of 100 parts by weight 25 of the dye (I) and the dye (II). If the content of the dye (III) exceeds 70 parts by weight, the degree of, for example, i-ray absorption rises, which tends to make the patterning through exposure to light difficult. In

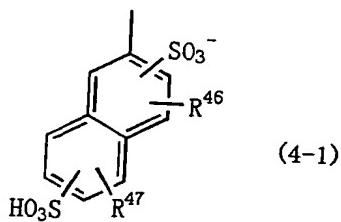
addition, the content of the dye (III) is usually 10 parts by weight or more, for a dye (III) content of less than 10 parts by weight tends to make the improvement of the spectroscopic characteristics unsatisfactory.

5       The green filter layer may comprise a triallylmethane dye (hereinafter, referred to as "dye (IV)") showing its absorption maximum at a wavelength within the range of from 580 to 680 nm. Examples of the dye (IV) include compounds represented by the general formula (IV-1):

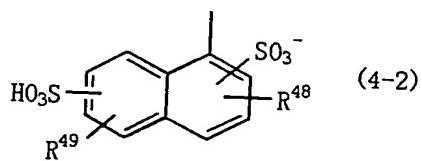
10



wherein R<sup>41</sup>, R<sup>42</sup>, R<sup>43</sup>, and R<sup>44</sup> each independently represents hydrogen atom, methyl group, or ethyl group; and  
15 R<sup>45</sup> represents a group represented by the general formula (4-1):

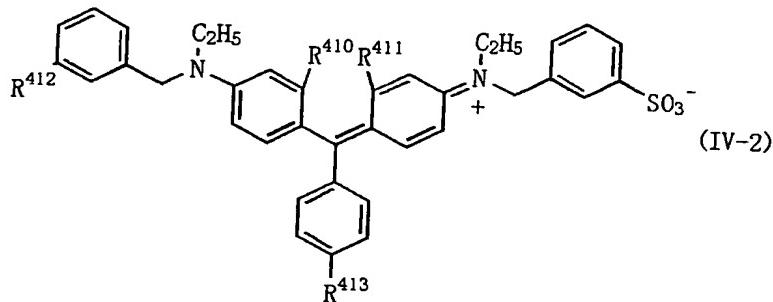


20       wherein R<sup>46</sup> represents hydrogen atom or amino group; and R<sup>47</sup> represents hydrogen atom or hydroxyl group or a group represented by the general formula (4-2):



wherein  $\text{R}^{48}$  represents hydrogen atom or amino group;  
and  $\text{R}^{49}$  represents hydrogen atom or hydroxyl group;

5 compounds represented by the general formula (IV-2):



wherein  $\text{R}^{410}$  and  $\text{R}^{411}$  each independently represents hydrogen  
10 atom or an alkyl group having 1 to 3 carbon atoms;  $\text{R}^{412}$   
represents hydrogen atom or a sulfonic acid group;  $\text{R}^{413}$   
represents hydrogen atom, a sulfonic acid group, a  
carboxylic acid group, an alkyl group having 1 to 3 carbon  
atoms, an alkoxy group having 1 to 3 carbon atoms, or a  
15 group represented by the general formula (41):



wherein  $\text{R}^{414}$  and  $\text{R}^{415}$  each independently represents  
hydrogen atom, phenyl group, an alkyl group having 1  
20 to 3 carbon atoms or a phenyl group substituted at the  
p-position with an alkoxy group having 1 to 3 carbon  
atoms; and  
salts thereof.

Incorporation of the dye (IV) can further improve spectroscopic characteristics while controlling a transmittance at 650 nm so as to be 10% or less with ease.

In a compound of the general formula (IV-2), examples 5 of the alkyl group having 1 to 3 carbon atoms and represented by R<sup>410</sup>, R<sup>411</sup>, R<sup>413</sup>, R<sup>414</sup>, or R<sup>415</sup> include methyl group, ethyl group, and propyl group. Examples of the alkoxy group having 1 to 3 carbon atoms and represented by R<sup>413</sup> include methoxy group, ethoxy group, and propoxy group. Examples 10 of the phenyl group substituted at the p-position with an alkoxy group having 1 to 3 carbon atoms and represented by R<sup>414</sup> or R<sup>415</sup> are p-methoxyphenyl group, p-ethoxyphenyl group, and p-propoxyphenyl group.

The dye (IV) may be a compound represented by the 15 general formula (IV-1), a compound of the general formula (IV-2), or a salt of the compound of the general formula (IV-1) or (IV-2).

Examples of the salt of a compound of the general formula (IV-2) include those with alkaline metals such as 20 sodium and potassium or with amines such as triethylamine, 2-ethylhexylamine and 1-amino-3-phenylbutane. The salt may be formed at the position of -SO<sub>3</sub>- residue or at a acid group represented by R<sup>412</sup> or R<sup>413</sup>.

Examples of the compound represented by the general 25 formula (IV-1) include C.I. Acid Green 16, C.I. Acid Blue 108, and C.I. Acid Green 50. Examples of the compound represented by the general formula (IV-2) or its salt include C.I. Acid Blue 7, C.I. Acid Blue 83, C.I. Acid Blue 90,

C.I. Solvent Blue 38, C.I. Acid Violet 17, C.I. Acid Violet 49, C.I. Acid Green 3, and C.I. Acid Green 9. These dyes (IV) are used singly or in combination. These dyes (IV) have their absorption maximum at a wavelength within the 5 range of from 580 to 680 nm.

In the case where the dye (IV) is used, its content is controlled so that the transmittance of the green filter layer is 5% or less at 450 nm, 62% or more at 535 nm, and 10% or less at 650 nm. Usually, the content of the dye 10 (IV) is adjusted so as to be 70 parts by weight or less per a total of 100 parts by weight of the dye (I) and the dye (II). A dye (IV) content exceeding 70 parts by weight tends to result in a decrease in transmittance at 535 nm. Preferably, the content of the dye (IV) is 5 parts by weight 15 or more, for a content of less than 5 parts by weight tends to make adjustment of its transmittance at 650 nm to 10% or less difficult.

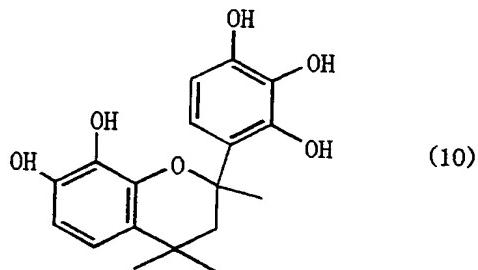
The color filter array of the present invention can be produced by an ordinary color resist method. For example, 20 it can be produced by a process comprising the step of patterning a photosensitive resin composition comprising colorants. The photosensitive resin composition comprises the dye (I) and the dye (II). The amounts of the dye (I) and the dye (II) comprised in the photosensitive 25 resin composition are individually the same as those in the desired green filter layer. If the green filter layer is desired to comprise other dyes, for example, the dye (III) and the dye (IV), a photosensitive resin composition

comprising the dye (III) and the dye (IV) is employed. The amounts of the dye (III) and the dye (IV) comprised in the photosensitive resin composition are the same as those in the desired green filter layer. The transmittance of the  
5 green filter layer after the patterning is 5% or less at 450 nm and 62% or more at 535 nm.

The photosensitive resin composition may be a positive photosensitive resin composition or a negative photosensitive resin composition.

10 The positive photosensitive resin composition of the present invention comprises, for example, a photoactive compound and an alkali-soluble resin in addition to the above-described dyes.

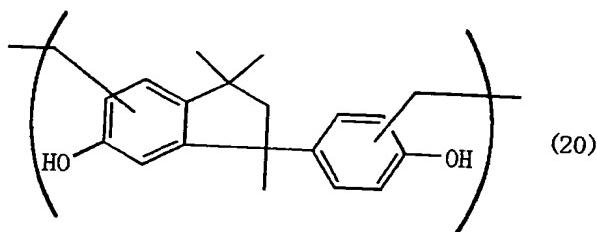
A photoactive compound used in conventional  
15 photosensitive resin compositions can be used in the positive photosensitive resin composition of the present invention. Examples thereof include esters of phenolic compounds with o-naphthoquinonediazide sulfonates. Examples of the phenolic compounds include compounds  
20 represented by the chemical formula (10).



As the o-naphthoquinonediazide sulfonates,

*o*-naphthoquinonediazide-5-sulfonate and  
*o*-naphthoquinonediazide-4-sulfonate can be exemplified.

The term "alkali-soluble resin" refers to resins that dissolve in alkaline developers, and any alkali-soluble resin similar to those used in conventional photosensitive resin compositions can be employed. Examples of such alkali-soluble resins include novolak resins such as those of p-cresol novolak resins, novolak resins of p-cresol and m-cresol; novolak resins having the structure represented by the formula (20):



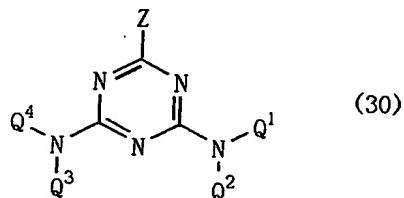
: polyvinylphenol; and copolymers of styrene with vinylphenol. Preferably, a novolak resin is employed as the alkali-soluble resin.

The amounts of the dyes, the photoactive compound, and the alkali-soluble resin comprised in the photosensitive resin composition are usually 25 to 55 parts by weight, 25 to 55 parts by weight, and 3 to 50 parts by weight, per a total of 100 parts by weight of the dyes, photoactive compound, and alkali-soluble resin, respectively.

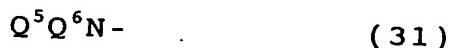
Into the positive photosensitive resin composition, a curing agent may be incorporated. Incorporation of the

curing agent improves the mechanical strength of the pattern formed by using the photosensitive resin composition.

As the curing agent, usually, a heat curing agent which is cured through heating is employed. Examples of the heat 5 curing agent include compounds represented by the general formula (30):



10 wherein Q<sup>1</sup>, Q<sup>2</sup>, Q<sup>3</sup>, and Q<sup>4</sup> each independently represents hydrogen atom, a hydroxyalkyl group having 1 to 4 carbon atoms, or an alkyl group having 1 to 4 carbon atoms and substituted with an alkoxy group having 1 to 4 carbon atoms; Z represents phenyl group or a group represented by the 15 general formula (31):



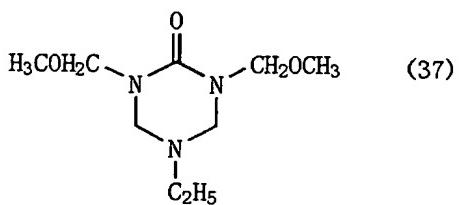
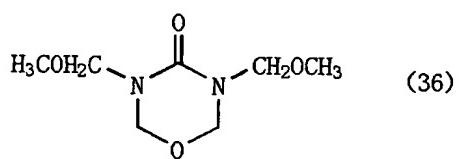
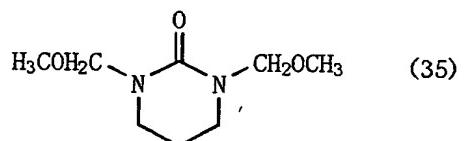
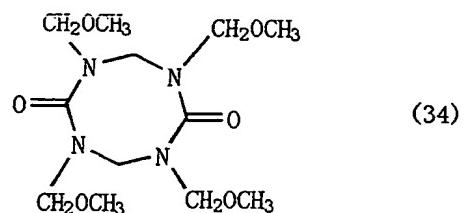
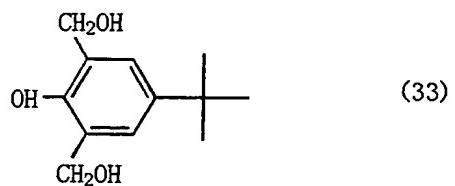
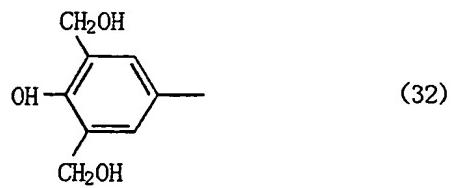
wherein Q<sup>5</sup> and Q<sup>6</sup> each independently represents hydrogen atom, a hydroxyalkyl group having 1 to 4 carbon atoms, or an alkyl group having 1 to 4 carbon atoms and 20 substituted with an alkoxy group having 1 to 4 carbon atoms

with the proviso that at least one of Q<sup>1</sup> to Q<sup>6</sup> is a hydroxyalkyl group having 1 to 4 carbon atoms or an alkyl group having 1 to 4 carbon atoms and substituted with an alkoxy group 25 having 1 to 4 carbon atoms.

Examples of the hydroxyalkyl group having 1 to 4 carbon atoms include hydroxymethyl group, hydroxyethyl group, hydroxypropyl group, and hydroxybutyl group. Examples of the alkyl group having 1 to 4 carbon atoms and substituted 5 with an alkoxy group having 1 to 4 carbon atoms include methoxymethyl group, methoxyethyl group, ethoxyethyl group, and propoxybutyl group.

An example of the compound represented by the general formula (30) is hexamethoxymethylmelamine.

10 Moreover, compounds of the following chemical formulae (32) to (37) can be used as the curing agent in the positive photosensitive resin composition of the present invention, for example.



When the curing agent is used, its content is usually not less than 10 parts by weight and not more than 35 parts by weight per a total of 100 parts by weight of the dyes, the photoactive compound, and the alkali-soluble resin.

The positive photosensitive resin composition of the present invention is usually diluted with a solvent.

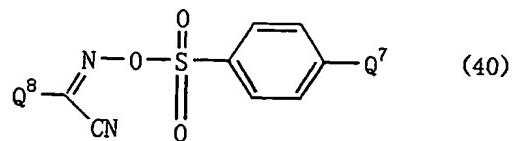
The solvent is suitably selected according to the

solubilities of the dye (I), dye (II), dye (III), dye (IV), photoactive compound, alkali-soluble resin, and curing agent, especially according to the solubilities of the dye (I), dye (II), dye (III), and dye (IV). For example, methyl  
5 cellosolve, ethyl cellosolve, methyl cellosolve acetate, ethyl cellosolve acetate, diethylene glycol dimethyl ether, ethylene glycol monoisopropyl ether, propylene glycol monomethyl ether, N-methylpyrrolidone,  $\gamma$ -butyrolactone, dimethyl sulfoxide, N,N'-dimethylformamide, cyclohexane,  
10 ethyl acetate, n-butyl acetate, propylene glycol monoethyl ether acetate, ethyl acetate, ethyl pyruvate, ethyl lactate, or the like can be employed. These solvents are used either singly or in combination.

The amount of the solvent to be used is usually about  
15 180 to 400 parts by weight per a total of 100 parts by weight of the dyes, photoactive compound, alkali-soluble resin, and curing agent.

The negative photosensitive resin composition of the present invention comprises, for example, a photoreactive  
20 acid generator, a curing agent, and an alkali-soluble resin, in addition to the dyes described above.

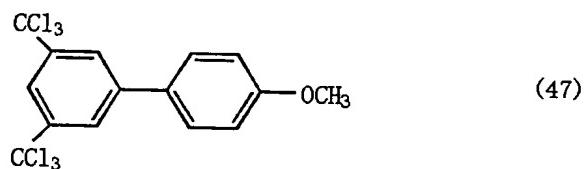
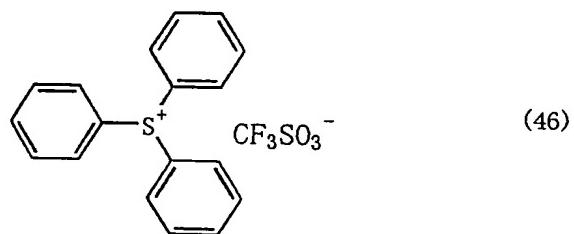
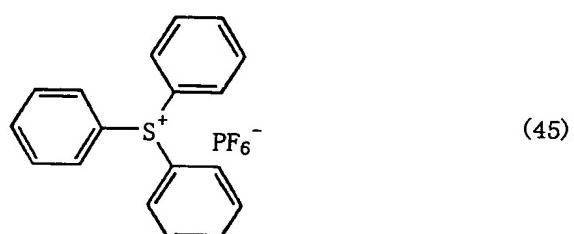
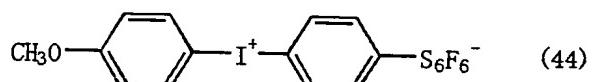
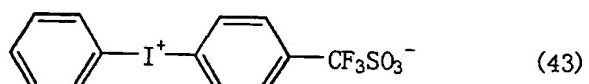
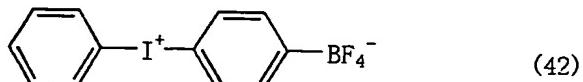
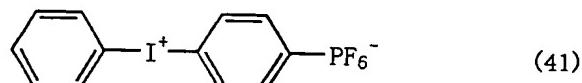
A photoreactive acid generator use in conventional negative photoreactive resin compositions can be employed as the photoreactive acid generator used in the negative  
25 photosensitive resin composition of the present invention. Examples thereof include compounds represented by the general formula (40):



wherein  $Q^7$  represents an alkyl group having 1 to 3 carbon atoms, and  $Q^8$  represents a phenyl group substituted with  
5 an alkyl group having 1 to 3 carbon atoms or a phenyl group substituted with an alkoxy group having 1 to 3 carbon atoms.

Examples of the alkyl group having 1 to 3 carbon atoms represented by  $Q^7$  include methyl group, ethyl group, and propyl group. An example of the phenyl group substituted  
10 with an alkyl group having 1 to 3 carbon atoms and represented by  $Q^8$  is o-isopropylphenyl group. Examples of the phenyl group substituted with an alkoxy group having 1 to 3 carbon atoms include p-methoxyphenyl group, p-ethoxyphenyl group, and p-propoxyphenyl group.

15 Moreover, compounds represented by the chemical formulae (41) to (47):



can also be used as the photo acid generator, for example.

As the curing agent, a heat curing agent which is cured  
5 through heating is usually employed as in the case of  
conventional negative photosensitive resin composition.  
The heat curing agents listed above as examples for the  
positive photosensitive resin composition can also be  
employed in the negative photosensitive resin composition  
10 of the present invention.

The alkali-soluble resins listed above as examples for the positive photosensitive resin composition can also be employed in the negative photosensitive resin composition of the present invention, as in the case of 5 conventional negative photosensitive resin composition.

The amounts of the photo acid generator, curing agent, and alkali-soluble resin comprised in the negative photosensitive resin composition per a total of 100 parts by weight of the dyes, photoreactive acid generator, curing 10 agent, and alkali-soluble resin are as follow. The content of the dyes is usually about 15 to 40 parts by weight, and that of the photo acid generator is usually 0.3 to 5 parts by weight. The amount of the curing agent to be used is usually 10 to 25 parts by weight, and the content of the 15 alkali-soluble resin is usually 20 to 75 parts by weight.

The negative photosensitive resin composition is usually diluted with a solvent.

The solvent is selected according to the solubilities of the dye (I), dye (II), dye (III), dye (IV), photo acid 20 generator, alkali-soluble resin, and curing agent, especially according to the solubilities of the dye (I), dye (II), dye (III), and dye (IV). The solvent listed above as examples for the positive photosensitive resin composition can be employed. The amount of the solvent 25 to be used is usually about 180 to 400 parts by weight per a total of 100 parts by weight of the dyes, photo acid generator, curing agent, and alkali-soluble resin.

Since the above-described photosensitive resin

composition employs the dye (I) and the dye (II) as its colorants, almost no precipitate is generated even if the composition is stored for a long period of time. Consequently, the composition can be applied onto the 5 substrate practically without irregularities. This makes it possible to provide a color filter array having a green filter layer with a pattern of about 0.5 to 2  $\mu\text{m}$  in thickness and about 2 to 20  $\mu\text{m}$  in length of each side.

The patterning is effected, for example, by providing 10 a coat of the above-described resin composition on a substrate, exposing the coat to light, and then developing.

The coat is provided on the substrate by applying a diluted photosensitive resin composition thereto. The composition is usually applied by spin coating. After the 15 composition has been applied onto the substrate, the coat is heated up to, for example, about 80 to 130°C to evaporate the solvent comprised therein. Thus, a coat of the photosensitive resin composition is obtained.

Thereafter, the coat is exposed to light. The 20 exposure to light involves the use of a mask pattern corresponding to the desired pattern, and is effected by irradiating the coat with a beam through the mask pattern. As the beam for the exposure of the coat to light, for example, g-ray, i-ray, or the like can be employed. Such an exposure equipment as the g-ray stepper or i-ray stepper may be 25 employed for the exposure. When a negative photosensitive resin composition is used, the coat is heated after the exposure to light. When the positive photosensitive resin

composition is used, the coat may be heated after the exposure or may not be heated. On heating the coat, the heating temperature is, for example, about 80 to 150°C.

After having been exposed to light, the coat is  
5 subjected to development. The development is effected by immersing the substrate provided with the coat in a developer, as in the case of the use of an ordinary photosensitive resin composition. Developer used for patterning conducted by using a conventional photosensitive resin  
10 composition can also be employed in patterning in the present invention. A color filter array having a green filter layer defined in the desired pattern can be obtained by taking the substrate out of the developer and then washing with water to remove the developer.

15 When a positive photosensitive resin composition is used, after having been washed with water, the substrate may be subjected to ultraviolet ray irradiation. Irradiation of ultraviolet rays can decompose the remaining photoactive compound. Moreover, when the photosensitive  
20 resin composition comprises a heat curing agent, the substrate may be heated after having been washed with water. By heating, the mechanical strength of the formed green filter layer can be improved. The heating temperature is usually not lower than 160°C and not higher than 220°C.  
25 Usually, the heating temperature is not higher than the decomposition temperatures of the dyes.

When a negative photosensitive resin composition is used, the substrate may be heated after having been washed

with water. By heating, the mechanical strength of the formed green filter layer is improved. The heating temperature is usually not lower than 160°C and not higher than 220°C. Usually, the heating temperature is not higher  
5 than the decomposition temperatures of the dyes.

Thus, a green filter layer in the desired pattern is formed. The other filter layers, that is, a red filter layer and a blue filter layer are formed in the same plane of the substrate which has been provided with the green  
10 filter layer, according, for example, to a conventional manner. When employing a positive photosensitive resin composition, it is preferred to employ one comprising a curing agent and carry out heating after development, for the strength of the formed green filter layer is improved.  
15 The green filter layer may be formed after the other color filter layers have been provided on the substrate.

Thus, a color filter array constituted of the red filter layer, green filter layer, and blue filter layer that are formed so as to be adjoining to each other in the  
20 same plane of the substrate can be obtained. The color filter array thus obtained is used for a solid-state image device, a liquid crystal display device, and the like. For instance, in the solid-state image device, if the color filter array is disposed on the front side of its  
25 charge-coupled device, color images excellent in color reproducitvity, especially in the reproducitvity of green color, can be obtained.

The color filter array of the present invention shows

excellent spectroscopic characteristics with respect to green light and has a green filter layer excellent in light fastness. Moreover, since dyes are employed as its colorants, the photosensitive resin composition to be  
5 employed for its production generates a less amount of precipitates and is excellent in store stability. As a result, a green filter layer less in foreign matter content, and uniform in thickness can be produced with ease. This color filter array is favorably employed for use in a liquid  
10 crystal display device or a solid-state image device comprising a charge-coupled device.

Hereinafter, the present invention will be described in more detail based on Examples, but these should by no means be construed as defining the scope of the present  
15 invention.

#### Example 1

After 2.5 parts by weight of C.I. Solvent Blue 67 as the dye (I), 3.5 parts by weight of C.I. Solvent Yellow  
20 162 as the dye (II), 3.5 parts by weight of C.I. Solvent Yellow 82 as the dye (III), 9 parts by weight of the ester of a phenolic compound represented by the chemical formula (10) with o-naphthoquinonediazide-5-sulfonate, as the photoactive compound, 7.5 parts by weight of a novolak resin  
25 of p-cresol as the alkali-soluble resin (weight average molecular weight in terms of polystyrene: 6,000), 5 parts by weight of hexamethoxymethylmelamine as the curing agent, and 70 parts by weight of ethyl lactate as the solvent had

been mixed and dissolved, the resulting mixture was filtrated with a membrane filter having a pore size of 0.1  $\mu\text{m}$  to provide a positive photosensitive resin composition.

A coat was formed by applying the positive  
5 photosensitive resin composition obtained above onto a substrate (silicon wafer) by spin coating and heating at 100°C for 1 minute to evaporate ethyl lactate therefrom. The coat had been exposed to light by irradiation of i-ray through a mask pattern using an exposure equipment ("Nikon  
10 NSR i7A" manufactured by Nikon Corp.). Then, the pattern was developed by immersing the coated substrate in a developer ("SOPD" manufactured by Sumitomo Chemical Co., Ltd.) at 23°C for 1 minute. After the development, the substrate was washed with water, dried, irradiated with  
15 ultraviolet rays, and heated to 180°C for 3 minutes to give a color filter array having a green filter layer in a striped-pattern (Figure 4). The green filter layer has a line width of 1.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ .

Thereafter, except using a different mask pattern,  
20 the same procedure as above was repeated to give a color filter array having a green filter layer formed in a mosaic pattern (Figure 5). The green filter layer has a line width of 2.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ .

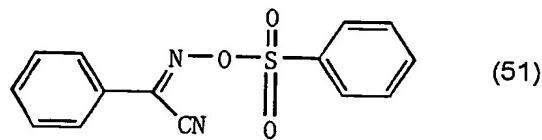
Except that a transparent glass plate was employed  
25 as the substrate in place of a silicon wafer and that the pattern was developed without being exposed to light, the same procedure as above was repeated to give a green filter layer formed in a thickness of 1.8  $\mu\text{m}$  all over the substrate.

Example 2

Except for using 0.7 part by weight of C.I. Acid Green 16 as the dye (IV) in addition to C.I. Solvent Blue 67 as 5 the dye (I), C.I. Solvent Yellow 162 as the dye (II) and C.I. Solvent Yellow 82 as the dye (III), the same procedure as in Example 1 was repeated to give a color filter array having a striped-pattern green filter layer with a line width of 1.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$  (Figure 4), a 10 color filter array having a mosaic-pattern green filter layer with a line width of 2.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ , and a green filter layer formed in a thickness of 1.8  $\mu\text{m}$  all over the substrate.

15 Example 3

After 2.5 parts by weight of C.I. Solvent Blue 67 as the dye (I), 3.5 parts by weight of C.I. Solvent Yellow 162 as the dye (II), 3.5 parts by weight of C.I. Solvent Yellow 82 as the dye (III), 0.5 parts by weight of a compound 20 represented by the chemical formula (51):



as the photo acid generator, 7.5 parts by weight of a novolak 25 resin of p-cresol as the alkali-soluble resin (weight average molecular weight in terms of polystyrene: 6,000),

5 parts by weight of hexamethoxymethylmelamine as the curing agent, and 70 parts by weight of ethyl lactate as the solvent had been mixed and dissolved, the resulting mixture was filtrated with a membrane filter having a pore size of 0.1  
5  $\mu\text{m}$  to provide a negative photosensitive resin composition.

A coat was formed by applying the negative photosensitive resin composition obtained above onto a substrate (silicon wafer) by spin coating and heating at 100°C for 1 minute to evaporate ethyl lactate therefrom.  
10 The coat had been exposed to light by irradiation of i-ray through a mask pattern using an exposure equipment ("Nikon NSR i7A" manufactured by Nikon Corp.), followed by heated at 120°C for 1 minute. Then, the pattern was developed by immersing the coated substrate in a developer ("SOPD"  
15 manufactured by Sumitomo Chemical Co., Ltd.) at 23°C for 1 minute. After the development, the substrate was washed with water, dried, irradiated with ultraviolet rays, and heated to 180°C for 3 minutes to give a color filter array having a green filter layer in a striped-pattern. The green  
20 filter layer has a line width of 1.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ .

Thereafter, except using a different mask pattern, the same procedure as in Example 1 was repeated to give a color filter array having a green filter layer formed  
25 in a mosaic pattern. The green filter layer has a line width of 2.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ .

Except that a transparent glass plate was employed as the substrate in place of a silicon wafer and that the

exposure to light was conducted without using the mask pattern, the same procedure as in Example 1 was repeated to give a green filter layer formed in a thickness of 1.8  $\mu$ m all over the substrate.

5

Example 4

A photosensitive resin composition for forming a green filter layer, a photosensitive resin composition for forming a red filter layer, and a photosensitive resin 10 composition for forming a blue filter layer were prepared according to the respective blending formulations shown below.

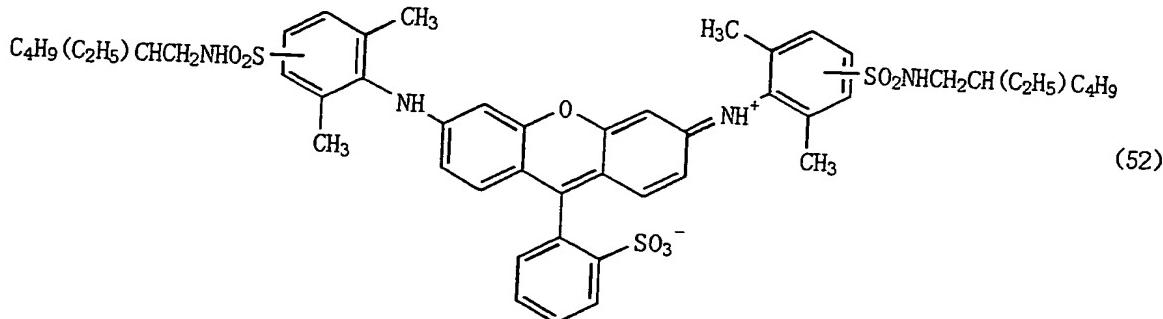
(Photosensitive resin composition for forming a red filter 15 layer)

Novolak resin	5 parts by weight
o-naphthoquinonediazide-4-sulfonate	8 parts by weight
Hexamethoxymethylmelamine	2 parts by weight
20 Ethyl lactate	50 parts by weight
N,N'-dimethylformamide	25 parts by weight
A compound represented by the chemical formula (52)	2 parts by weight
C.I. Solvent Orange 56	2 parts by weight
25 C.I. Solvent Yellow 82	2 parts by weight
C.I. Solvent Yellow 162	2 parts by weight

(Photosensitive resin composition for forming a blue filter

layer)

	Novolak resin	5 parts by weight
	o-naphthoquinonediazide-4-sulfonate ester	8 parts by weight
5	Hexamethoxymethylmelamine	2 parts by weight
	Ethyl lactate	50 parts by weight
	N,N'-dimethylformamide	25 parts by weight
	A compound represented by the chemical formula (52)	
10	C.I. Solvent Blue 25	3 parts by weight
	C.I. Acid Blue 90	3 parts by weight
		2 parts by weight
	(Photosensitive resin composition for forming a green filter layer)	
15	Novolak resin	5 parts by weight
	o-naphthoquinonediazide-4-sulfonate ester	8 parts by weight
	Hexamethoxymethylmelamine	
20	Ethyl lactate	2 parts by weight
	N,N'-dimethylformamide	50 parts by weight
	C.I. Solvent Blue 25	25 parts by weight
	C.I. Solvent Yellow 82	4 parts by weight
	C.I. Solvent Yellow 162	2 parts by weight
		2 parts by weight



The photosensitive resin composition for forming a red filter layer prepared above had been applied onto a silicon wafer provided with a charge-coupled device constituted of a over coating film (3), a polysilicon electrode (4), a sensor (5), a V resistor (6), a light-shielding film (7), and a passivation film (8) by spin coating. Then, its solvent was evaporated off on a baking plate at 100°C.

Thereafter, using an i-ray stepper exposure equipment ("Nikon NSR2205 i12D" manufactured by Nikon Corp.), the substrate was irradiated with an ultraviolet ray of a wavelength of 365 nm through a reticle ( $2,000 \text{ mJ/cm}^2$ ). Then, the substrate was subjected to development by a developing agent (an aqueous solution containing 30g of tetramethylammonium hydroxide per  $1,000 \text{ cm}^3$ ). After the exposed portion had been removed, the substrate was washed with pure water. Thereafter, using a low-pressure mercury lamp ( $3,000 \text{ mJ/cm}^2$ ), ultraviolet rays were irradiated all over the substrate, and the substrate was then heated on a baking plate at  $180^\circ\text{C}$  for 10 minutes to form a red filter layer (Figure 6 (a)).

Except for using the photosensitive resin composition for forming a blue filter layer prepared above instead of the photosensitive resin composition for forming a red filter layer, the same procedure as above was repeated to  
5 form a blue filter layer (Figure 6 (b)).

Except for using the photosensitive resin composition for forming a green filter layer prepared above, the same procedure as above was repeated to form a green filter layer and consequently a color filter array(Figure 6 (c), (d)).

10 A microlens was formed on the color filter array in a conventional manner to give a solid-state image device. The thickness of the green filter layer of the color filter array at the solid-state image device was  $1.7 \mu\text{m}$ . The color filter array at this solid-state image device showed good  
15 spectroscopic characteristics (Figure 6 (e)).

In the same manner as that described above, a green filter layer (thickness:  $1.7 \mu\text{m}$ ) was formed all over a quartz wafer.

## 20 Example 5

Except that the following photosensitive resin composition was employed as the photosensitive resin composition for forming a green filter layer, the same procedure as that in Example 4 was repeated to give a  
25 solid-state image device, and a green filter layer (thickness:  $1.7 \mu\text{m}$ ) was formed.

(Photosensitive resin composition for forming a green

filter layer)

Novolak resin                    5 parts by weight

o-naphthoquinonediazide-4-sulfonate ester  
                                  8 parts by weight

5 Hexamethoxymethylmelamine 2 parts by weight

Ethyl lactate                    50 parts by weight

N,N'-dimethylformamide        25 parts by weight

C.I. Solvent Blue 25 (dye (I))  
                                  3 parts by weight

10 C.I. Solvent Yellow 82 (dye (III))  
                                  2 parts by weight

C.I. Solvent Yellow 162 (dye (II))  
                                  2 parts by weight

C.I. Acid Green 16 (dye (IV))  
                                  1 part by weight

The color filter array at the solid-state image device obtained above showed improved spectroscopic characteristics.

20 Measurements made on the green filter layer (thickness: 1.7  $\mu$ m) formed on the quartz wafer revealed its transmittance as to be 1% at a wavelength of 450 nm, 67% at a wavelength of 535 nm, and 4% at a wavelength of 650 nm.

25 Comparative Example 1

After 2.5 parts by weight of C.I. Solvent Blue 67 as the dye (I), 7 parts by weight of C.I. Acid Yellow 40 as

a dye, 9 parts by weight of the ester of a phenolic compound represented by the chemical formula (30) with o-naphthoquinonediazide-5-sulfonate, as the photoactive compound, 7.5 parts by weight of the novolak resin of 5 p-cresol (weight average molecular weight: 6,000 on polystyrene basis), as the alkali-soluble resin, 5 parts by weight of hexamethoxymethylmelamine as the curing agent, and 70 parts by weight of ethyl lactate as the solvent had been mixed and dissolved, the resulting mixture was 10 filtrated with a membrane filter having a pore size of 0.1  $\mu\text{m}$  to give a positive photosensitive resin composition.

Thereafter, except for using the positive photosensitive resin composition obtained above, the same procedure as in Example 1 was repeated to give a color filter array having a striped pattern green filter layer having a line width of 1.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ ; a color filter array having a mosaic pattern green filter layer having a line width of 2.0  $\mu\text{m}$  and a thickness of 1.8  $\mu\text{m}$ ; and a color filter array all over of which is provided 15 with a 1.8  $\mu\text{m}$ -thick green filter layer.

#### Evaluation

##### (1) Spectroscopic characteristics

The color filter arrays each provided with a green 25 filter layer all over its substrate and obtained in Examples and Comparative Example were subjected to measurement of light transmittance at 450 nm, 535 nm, and 650 nm. The results are shown in Table 1.

(2) Light fastness

An ultraviolet ray-blocking filter ("colored optical glass L38" manufactured by Hoya Corp. Capable of blocking light of a wavelength of 380 nm or shorter) was disposed  
5 in front of each of the color filter arrays obtained in Examples and Comparative Example and provided with a green filter layer all over its substrate, followed by irradiating light at 1,000,000 lx · hour. "Sun tester XF 180 CPS" manufactured by Shimadzu Corp. was employed as the light  
10 source. The light transmittance of each color filter array after the irradiation was measured at a wavelength of 450 nm, 535 nm, and 650 nm. The results are shown in Table 2.

15 [Table 1]

	Light transmittance (%)		
Wavelength (nm)	450	535	650
Example 1	0.4	68	13
Example 2	0.4	67	5
Example 3	0.4	69	13
Example 4	1.0	70	13
Example 5	1.0	67	4
Comparative example 1	0.4	68	13

[Table 2]

	Light transmittance (%)		
Wavelength (nm)	450	535	650
Example 1	1.5	74	15
Example 2	0.4	67	16
Example 3	1.5	75	15
Example 4	2.0	68	13
Example 5	2.0	64	8
Comparative example 1	17	74	15